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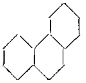
EDITORIAL

Phenanthrene

It has always appeared to us that the skill of the chemist in building up complicated structures from *benzene rings and other groups is simply amazing.* It is really a most remarkable thing that the chemist should be able to make naphthalene and phenanthrene  and then should be able to pick out one or two carbon atoms in the special positions that he chooses and substitute for the hydrogens attached to them particular elements or groups so as to make new compounds and form fresh rings, whether benzene rings or not, just as he pleases. To learn how to perform these tricks has taken fifty years of study and has involved the publication of scores of papers in the Transactions of sundry chemical societies but it has been well worth while, for such knowledge has been and is of great theoretical and practical importance. By the way, we wish some chemist would tell us how the three rings in phenanthrene are arranged in space so that we can form a clearer picture of the lie of the land. The phenanthrene group seems to occur in plants and animals, for morphine and cholesterol are both derived from it and we are much interested to learn from the paper we publish this week by Dr. J. W. Cook and Mr. C. L. Hewett that they have devised a promising method of synthesis of complex compounds containing the phenanthrene ring-system. This seems to afford an opportunity for a synthesis of the sterols and bile acids and the further developments of this important method will be awaited with eagerness. The vitamins which seemed to be such elusive and delicate substances are in process of being isolated and crystallized and the next stage will be their synthesis. We cannot be satisfied until human beings can perform experiments that are *easily achieved by such inferior organisms as* diatoms, carrots, and halibut.

The Newest Elements

With our atomic numbers, our periodic law, our spectra, and our positive rays we are beginning to feel *pretty positive about our elements. New members of* the family have of late been dragged into the glare of human inspection with sufficient rapidity and regularity to make the event seem almost a passing item of interest; yet we are, presumably, near the end of the game: the race for the Elementary Stakes is nearly over. What would the Greeks think about it all were they here to see? Thales, who believed water to be the one primary element; Anaximenes, whose air condensed first to water and then to earth; Heraclitus, to whom the primary reality was ethereal fire; Pythagoras, Empe*docles, and Aristotle with their four-element world?* Even if we add the mediæval qualities mercury, sulphur, and salt; or go further until we come to the time when Boyle laid the foundation of a clean sweep of the older ideas, though the broom was wielded by others; or trace the fascinating story of the discovery, one by one, of the materials we now call elements (as, for instance, has been done in a series of articles which has lately been published in the *Journal of Chemical Education*); or remember how we have learned that many of them are not so simple as we once thought, we can scarcely find a more interesting reflexion than that which is almost immediately to be forced upon us: is not the discovery of elements really at an end, except possibly for an ever lengthening list of isotopes? As every schoolboy knows, it was Robert Boyle who changed the prevailing conception of an element by his famous formulation: "It may likewise be granted, that those distinct substances, which Concretes generally either afford or are made up of, may without very much Inconvenience be call'd the Elements or Principles of them." And as every student knows, it was the work of Moseley, whose physical measurements placed the elements in nearly the same order as a mere enumeration in atomic weight order had done—with the advantage that anomalies then disappeared—which defined the probable number of elements, and greatly stimulated researches having in view the discovery of those that then remained unknown. Among the junior members of the

family of elements is hafnium, which is associated in nature with zirconium compounds, and is stated to be far more abundant than silver or gold. Dauvillier and de Broglie's *X*-ray study of rare earth residues had resulted in their attributing certain lines to element 72, which they named celtium, but Coster and von Hevesy, starting with the conviction that the element would resemble zirconium rather than the rare earths, successfully reached their goal at Copenhagen in 1923. Of the two elements, "ekamanganese" and "dwimanganese" reported in 1924 by Noddack, Tacke, and Berg in Berlin after a search in platinum ores and columbite, one has survived further study, but of the other we yet hear little. Masurium (43) exists in scarcely more than name, whilst rhenium (75), also shown by Loring and Druce and by Dolejšek and Heyrovský to be associated with manganese in its salts, is now an article of commerce, and is the subject of numerous chemical investigations. Illinium (61), a rare earth, was discovered in 1926 by Hopkins and his co-workers of the University of Illinois, who worked on residues from monazite; two years previously Rolla, of Florence, had detected lines due to the new element, which he called florentium, but his results were not published until later. There remain the elements of atomic numbers 87 and 85, the former an alkali metal, and the latter a halogen; these two provide the theme of the most recent chapter of this wonderful record. In 1931 Papish and Wainer, of Cornell University, concentrated the cæsium in a uranium-rich samarskite, and found *X*-ray lines corresponding with element 87; independent evidence of its existence has been obtained by Barnes and Gibson. Allison and his co-workers in Alabama have developed a new technique which they have applied to the detection of minute quantities of chemical substances in aqueous solution. It depends on measuring the time lag between the application of a magnetic field and the appearance of the Faraday effect, the rotation of the plane of polarization caused by the passage of a beam of light through a magnetic field. Solutions of pollucite and lepidolite gave minima attributed to element 87, which has been named virginium, and other experiments on solutions prepared from monazite sand are considered to indicate the presence of element 85, to which the name alabamine has been given. A difficulty, however, lies in the fact that preparations thus found to contain much virginium did not respond to the *X*-ray test, and in other cases also the results have been found to differ from those obtained by means of the mass-spectrograph. Apart from these two uncertainties and masurium, we have completed our list, and even added an "extra" in the neutron, which might be regarded as an element of zero atomic number. There is the further possibility that elements heavier than uranium might exist, although this is unlikely. Strictly, we should include in our short survey of new elementary discoveries the numerous new isotopes which have been added to the list. During 1932 our knowledge of the isotopic composition of no less than twenty-one elements was extended. Of these observations the most arresting is the announcement of the existence of an isotope of hydrogen of mass 2. In samples obtained by evaporation of hydrogen near the triple point faint Balmer-spectrum lines of H^2 have been found by Urey, Brickwedde, and Murphy; the new isotope can also be concentrated by the fractional electrolysis of water. Since there is relatively so great a difference between the masses of H^1 and H^2, the ease with which H^2 can be concentrated is scarcely surprising. The infra-red absorption spectrum of hydrogen chloride affords evidence of the presence of H^2Cl^{35} and H^2Cl^{37}, and ordinary hydrogen chloride contains 1 part of H^2Cl in 35,000. Search has even been made for isotopes H^3, He^3, and He^5, but none of these has been detected. All of which brings us back, as Whitehead reminds us, to Pythagoras and his theory that ultimate reality is to be found in numbers and their relations.

Heavy Water

Most of us were brought up to regard the atom, as defined by Dalton, to be like the sovereign—a permanent indestructible standard of belief. In recent years the physicists have demonstrated that there may be protons and electrons smaller than the atom and that of any given atom there are isotopes, a name first suggested by Soddy. Newest of all is the neutron, which has been discovered by Dr. J. Chadwick, and appears to be a complex particle formed by the union of a proton and an electron with mass 1 and zero charge. The work of Aston has in course of time revealed isotopes of nearly all the elements so that the older atomic weights have lost almost all their significance. Perhaps the most interesting of all these is the isotope of hydrogen of mass 2, or double that of ordinary hydrogen: it would appear to be a neutron plus a proton. These two isotopes can be more easily separated than is usually possible owing to the relatively considerable difference between the two masses and as a consequence H^2 and its compounds have become very fashionable materials for research. Chief among these of course, is water made from the heavier hydrogen. Apparently on electrolysis lighter waters are decomposed more easily than the heavier forms so that the residual water of cells which have been operated for a few years has a markedly higher content of heavy water. Prof. G. N. Lewis of California has concentrated the heavy form to obtain a sample containing nearly thirty-five per cent. of it with a specific gravity of 1·035 and we are told has reached a much higher concentration quite recently. Certainly the new heavy water will differ in all physical ways from the old though it is unlikely that it will show detectable chemical differences. Whilst attention has so far been directed to the new water, there will be some undoubtedly who will ask what of the new alcohol. With regard to hydrogen itself, the mass change is so great that the isotope is expected to behave somewhat differently chemically like the difference between two halogens perhaps. It may conceivably be expected to be very useful in organic chemical reactions to "mark" one of the hydrogens in a radicle when one suspects a re-arrangement or migration to be taking place. On the other hand it is a little doubtful if any biological implications will be discovered. Such are among the salient points towards which attention is bound to be directed. It is an amazing development of the atomic structure story.

THE POSITIVE PROCESS IN PHOTOGRAPHY

By H. BAINES, D.Sc., F.I.C., F.R.P.S.

THE NECESSITY OF THE NEGATIVE–POSITIVE PROCESS

Salts of silver owe their unrivalled position as the basis of so many photographic processes to the two properties of high sensitivity to light, and ease of conversion into very stable insoluble derivatives. These derivatives, of which the metal and the sulphide are the most important examples, are dark in colour, and under ordinary conditions the quantities produced increase progressively with increasing light action. For these reasons, the brighter the light falling on a portion of a material during exposure, the blacker will be the deposit, and hence the single operation of exposure, development, and fixation of a silver halide emulsion must produce a negative image of an object, and the production of a positive image must necessarily comprise the two processes of the formation of a negative image, and the production from it of a positive image (*i.e.*, a negative of the negative). The discovery of a stable white derivative of silver would make it possible to produce a direct positive result when viewed by reflected light, by the process of coating a sensitive emulsion on a black support and converting the exposed sensitive silver compound into the white insoluble derivative. Again, a simple method of developing the unexposed portion of the silver image instead of the exposed portion would produce a direct positive, but until some such advance as this has been made, the negative-positive process must continue to be almost universally used.

The positive exposure.—A positive is obtained from a negative by exposing sensitive material in contact with the coated side of the negative, or by exposing it in a position coincident with the real image of the negative in some optical system. In either case the negative is uniformly illuminated, and light falls on the positive material after transmission by the negative. All portions of the positive material are thus exposed for the same time, but different portions receive different exposures, according to the variations in intensity caused by differences in opacity of corresponding portions of the negative. It has been explained (CHEM. & IND., 1931, p. 707) that density* is measured as the logarithm of the opacity; that is, if a uniform intensity of I metre-candles falls on the negative, the density D_1 which transmits an intensity of I_1 is given by the formula:

$$D_1 = \log \text{opacity} = \log \frac{I}{I_1} = \log I - \log I_1.$$

If I_2 is the intensity transmitted by a density D_2, then $D_1 - D_2 = -(\log I_1 - \log I_2)$. The exposures E_1 and E_2, received by portions of a positive material exposed behind these densities will be equal to the intensities I_1 and I_2, multiplied by a constant factor, *t*, the time of exposure. The difference between the exposure logarithms at any two parts of the positive will therefore be equal to the difference between the intensity logarithms, since the logarithm of the time factor cancels out. That is to say,

$$(D_1 - D_2)\ (\text{negative}) = -(\log E_1 - \log E_2)\ (\text{positive}).$$

Thus the log exposure difference between any two parts of the positive will be numerically equal to the density difference between the corresponding portions of the negative. The minus sign merely indicates that the lower density gives the greater exposure.

Tone reproduction.—Positive materials, whether for transmission purposes (cine positive film, lantern slides, transparencies, etc.) or for viewing by reflected light (photographic papers etc.) behave similarly to negative materials in giving a linear relationship between log exposure and density over a portion of the characteristic curve (see article cited), and if the straight line portions of both negative and positive characteristic curves be used in producing a photograph, we can deduce proportionality between the tone values of the original object and those of the positive image, thus: the visual tone values of a subject are directly proportional to the logarithms of the local brightnesses or intensities and hence to the logarithms of the exposures acting on the negative material (*loc. cit.*, p. 706). If the straight line portion of the negative characteristic curve is used the negative densities are proportional to these log exposure values. *It has been shown (above) that increments of density* of the negative are numerically equal to increments of log exposure of the positive, and the latter increments, using the straight line portion of the positive curve are proportional to the positive densities. From reasons already advanced, it can be seen that increments in density of the positive material are numerically equal to differences in log intensities of the positive (transmission or reflexion) when under uniform illumination, and these log intensities are proportional to the tone values of the positive image. The net result is direct proportionality between the tone values of the subject and of the positive image.

This chain of reasoning may be expressed more concisely by considering the interval between any *two tone values of the subject;* T_1 *and* T_2. *Then:*

$$\underbrace{T_1 - T_2}_{\text{tone value of subject}} = \underbrace{K_1(\log I_1 - \log I_2)}_{\text{log intensity from subject}} = \underbrace{K_1(\log E_1 - \log E_2)}_{\text{log exposure of negative}}$$

$$= \underbrace{K_1K_2(D_1 - D_2)}_{\text{density of negative}} = \underbrace{-K_1K_2(\log E_1 - \log E_2)}_{\text{log exposure of positive}} = \underbrace{-K_1K_2K_3(D_1 - D_2)}_{\text{density of positive}}$$

$$= \underbrace{+K_1K_2K_3(\log I_1 - \log I_2)}_{\text{log intensity from positive under uniform illumination}} = \underbrace{\frac{K_1K_2K_3}{K_1}(T_1 - T_2) \text{ or } K_2K_3(T_1 - T_2)}_{\text{tone value of positive}}$$

It will be seen that if the product of the constants K_2 and K_3 were equal to unity, then intervals of tone value of the subject would be equal to those of the positive, *i.e.*, there would be no increase or decrease in contrast. These two constants define the relation between the log exposure and density of the negative and of the positive material respectively, and they are equal to the reciprocals of the respective "gammas" (*loc. cit.*, p. 708). Hence to preserve the original contrast of the object in a photographic reproduction

* *Owing to the light-scattering property of a silver image, the intensity varies according to the method of printing employed—contact or projection* (CHEM. & IND., 1932, p. 178), *and the appropriate density value is assumed in the above reasoning.*

process, the product of the negative and positive gammas must be unity.

While it is quite possible to obtain proportional tone reproduction in this way, it is undesirable for two reasons; (*a*) the straight line portion of the characteristic curve of the positive material is comparatively short, in some cases being merely a point of inflexion;

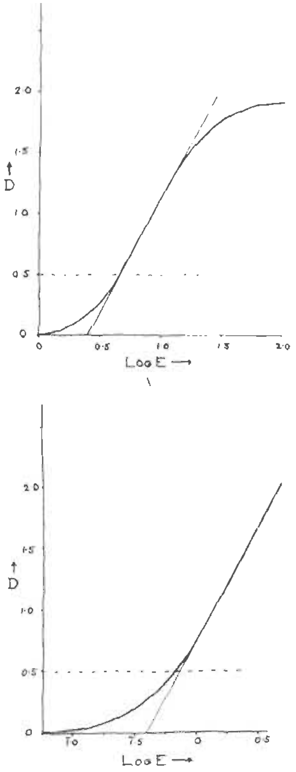


Fig. 1

(*b*) the lightest tones of the positive print, whether on paper or film, are preferably represented by a density approximating to zero. Consideration of typical characteristic curves of a bromide printing paper and a cine positive film (Fig. 1) shows that the lowest density on the straight line portion is of the order 0·5. Images with densities on the straight line portion only would therefore be very unsatisfactory; the result on paper would be extremely murky (Fig. 2), while that on cine positive film would be equivalent to reducing the projecting light to less than one-third of its candle power.

"*Reslaw Hats.*" *Photo by Tunbridge.*
Normal print, with lowest density approximately zero

"*Reslaw Hats.*" *Photo by Tunbridge.*
Print with lowest density on straight line portion of positive curve

Fig. 2

Characteristics of Positive Printing Papers

Maximum density (*D max*).—Since we are thus forced to use more of the positive curve than the straight line portion, the characteristics of positive materials should here be examined in closer detail. While most negative materials are capable of yielding maximum transmission densities of above 3, the highest reflexion density obtainable from gelatin development emulsions on paper varies from 1·4 to 2·0 according to the surface and other characteristics. Taking antilogs, we see that the intensity of light from the brightest portion of a print is from 25 to 100 times that from the darkest portion. As the intensity range of an average sunlit scene is about 1 to 30, it will be seen that for many subjects practically the whole range of densities of which the paper is capable should be used, and hence the maximum density (D max) of positive materials is a much more important factor than that of negative materials.

Cut.—Since we are compelled to use the under-exposure portion of a positive material, the contrast in the highlights, which gives the sparkling quality to prints, will be governed, not by the gamma of the paper, but by the characteristics of the foot of the curve. Hurter and Driffield pointed out that in the under-exposure period of a photographic material, a linear relationship exists between the density and the exposure. That is to say that the foot of the usual D-log E curve is represented by a pure logarithmic curve. The subject was examined in greater detail by F. F. Renwick, who showed that the density at which a linear relation between density and exposure ceases is identical with that at which a linear relation between density and log exposure commences. That is to say there is no intermediate region in which neither rule holds, and therefore a characteristic curve is merely a logarithmic curve with a tangent at some point governed by the slope of the tangent.

Fig. 3B shows the foot of the characteristic curve of cine positive film, and in Fig. 3A the density is plotted against the exposure. The transition density is marked, and the broken curve in Fig. 3B shows a continuation of the logarithmic curve given by the under-exposure period.

The continuation of the straight line portion of the D-E curve rarely passes through the origin, but meets the D axis at some distance, *c*, below this. The general equation covering this straight-line section is therefore $D + c = uE$, where *u* is a constant for each material. On the D-log E curve, the factor *u* becomes an addition of log *u*, and hence merely moves the curve bodily along the log E axis, without affecting its shape. With the exception of certain complex materials of modern commerce the under-exposure periods of all photographic materials thus consist of sections of one logarithmic curve, which varies only in its position. The variations in the value *c* has the effect on the D-log E curve of shifting the fundamental logarithmic curve up or down the D axis in such a way that the greater the value of *c* the larger the horizontal slice which is removed from the bottom of the complete logarithmic curve. It follows that the contrast of the extreme foot of the characteristic curve increases with the value *c*; thus, neglecting fog, while the density of a material of zero *c* value increases with exposure by infinitely small steps from zero at a log E value of minus infinity, that of a material of high *c* value increases fairly rapidly from zero at a definite log E value. This distinction, though real, is not quite rigid, owing to a deviation from the linear relation between D and E near the E axis. That is to say, there is a secondary "foot" to the foot of the characteristic curve. The name "cut" was suggested by Renwick for the value *c*, and its magnitude is of considerable importance in the definition of the characteristics of positive materials.

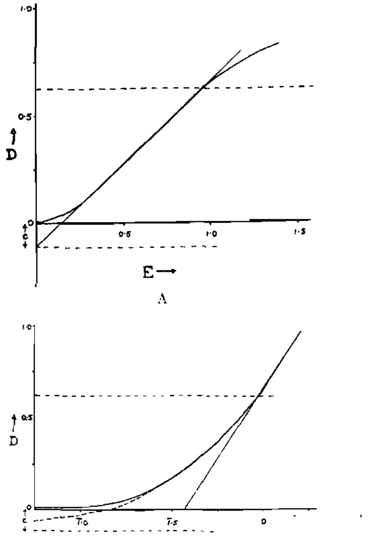


Fig. 3

The contrast of the under-exposure and straight line portions of the characteristic curves of positive materials can thus be fairly accurately defined by the gamma and cut values, but in the case of photographic printing papers, these values alone are insufficient, since the whole range of densities, including the over-exposure portion, must often be used.

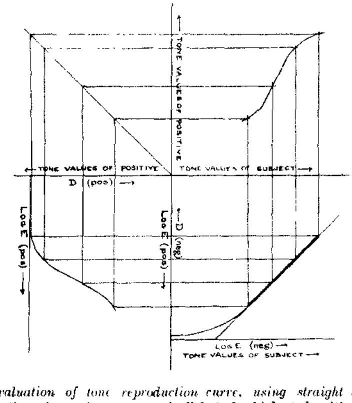
Average gradient $\bar{G}(D)$.—The evaluation of the contrast function of printing papers has been carefully studied by Lloyd A. Jones, who concluded from fundamental psychophysical laws that the appearance of contrast in a positive print is best expressed as a function of the range of densities, and of the average gradation throughout the characteristic curve (the readings to be

averaged being taken at equal density intervals not at equal log exposure intervals). The average gradient, which he expressed as $\bar{G}(D)$ is conveniently evaluated by averaging the gradients at ten equidistant densities, the highest and lowest density corresponding to the minimum useful gradient, which is defined by Lloyd Jones as 0·2. As a result of many tests with various observers, he found that the visual estimation of total contrast was most nearly reproduced by

$$\Omega = \frac{(D\,max - D\,min)\,\bar{G}(D)}{(I\Delta D)^2}$$

where Ω = visual contrast, D max = maximum density, D min = minimum density, $\bar{G}(D)$ = average gradient, with respect to density. $I\Delta D$ = the least perceptible density difference, and is approximately constant and equal to 0·007. This unit was considered to be more fundamental than unit density as commonly understood, since its inclusion enables the contrast to be expressed in terms of the total number of visible steps in density a particular material is capable of.

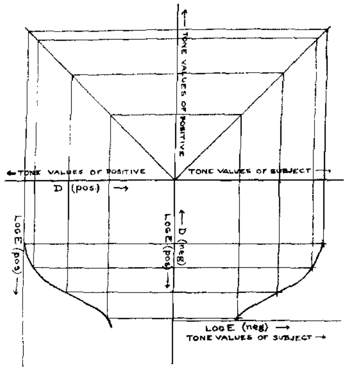
The tone reproduction diagram.—An ingenious graphic method was devised by F. F. Renwick, for the computation of the accuracy of tone reproduction from the characteristics of the negative and positive materials used. An alternative method was later worked out by Lloyd A. Jones, which is expanded in greater detail than Renwick's method, and therefore easier for demonstration purposes.



Evaluation of tone reproduction curve, using straight line portion of negative curve, and all but the highest densities of the positive curve

FIG. 4

Jones's diagram is shown in Fig. 4, and its use can be illustrated by determining the general accuracy of tone reproduction, when the straight line portion of the negative curve is used, and a print is obtained by using all but the maximum densities of the positive paper. The characteristic curve of the negative material is shown in the lower right-hand quadrant, and the straight line portion used is denoted by a thickening of the line. The horizontal axis represents log E values, and therefore tone values of the subject. The vertical axis represents



Determination of required negative characteristics to give perfect tone reproduction with a typical positive material

FIG. 5

negative densities, and hence in an opposite sense the log E exposure values of the positive. We can translate these positive log E values into positive densities by plotting the characteristic curve of the positive material in the lower left-hand quadrant, but owing to the position of the log E axis, the positive densities will be plotted on a horizontal axis. By reversing the sign, the positive densities can represent the tone values of the positive. These values can be transferred by means of the 45° line in the upper left-hand quadrant to the vertical axis of the upper right-hand quadrant, which thus shows the relation between corresponding tone values of subject and positive print, *i.e.*, the tone reproduction curve. The curve itself is obtained by following specific values round the quadrants as shown in the diagram, from tone values of subject to those of the positive, and to the intersection points in the upper right-hand quadrant. The straight line portion of the tone reproduction curve corresponds to the period of correct tone reproduction, and it will be seen that the deviations from this are introduced by the under- and over-exposure periods of the positive characteristic curve.

It has been shown that on printing paper we must necessarily use these periods in photographic reproduction, but they could be compensated for by the use of a negative material of suitable characteristics. In Fig. 5 the necessary characteristic curve of this negative material is obtained in the lower right-hand quadrant by the intersection of the lines drawn from the positive characteristic curve, correct tone reproduction being

represented by the straight line in the upper right-hand quadrant.

No negative materials of commerce have characteristic curves similar to that deduced in Fig. 5, and indeed if such a one could be made, its usefulness would be very limited, since it would give correct tone reproduction over the whole of the positive densities, only when the negative receives a certain definite exposure to a subject of a defined range of tone values. In general, however, it can be seen that the deduced curve bears a closer resemblance to the under-exposure portion of a negative curve than to the straight line portion, and in practice better tone reproduction is obtained by using this portion.

Fig. 6 applies Jones's method of the determination of tone reproduction, when the under-exposure portion

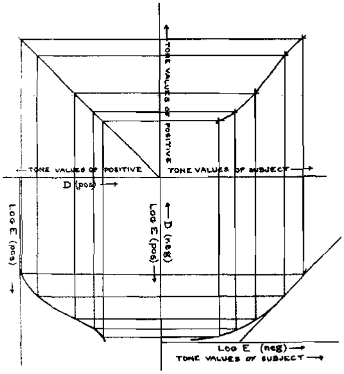


Illustration of conditions giving best tone reproduction—use of under-exposure portion of negative curve, and all but the highest densities of positive material

Fig. 6

of the negative is used, and a print obtained, using all but the highest positive densities. It will be seen that the resultant tone reproduction curve approximates more closely to a straight line (*i.e.*, correct tone reproduction) than when only the straight line portion of the negative curve is used. The use of the under-exposure period of the negative material offers other advantages. In the first place the minimum exposure is decreased and the effective speed of the material consequently increased. Again the graininess of the image is decreased, since this property decreases with decreasing density.

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THE CORNER METALS OF ELECTRICAL DISTRIBUTION: COPPER, ALUMINIUM, AND LEAD*

By F. J. BRISLEE, D.Sc., F.I.C., F.R.M.S.

The three metals which are associated in the distribution of electrical energy are among the most important metals in the world of industry. Copper and lead were known to the ancients, and it is a matter of historical interest that copper had many uses in the domestic and economic life of the very earliest of mankind. It is probable that a number of alloys which would now be called bronze and brass were confused with copper in the early history of the metal. There is a noted passage in the Book of Job to the effect that "iron is digged out of the earth, and brass is molten out of the stone"—obviously referring to the production of an alloy from some naturally occurring ore. It is also probable that a high degree of skill of working of copper was developed, and records exist of very large castings of copper and bronze pillars or statues.

The extraction of copper from its ores and the subsequent purification of the metal and conversion into a workable form is one of the most complex processes in metallurgy. About the beginning of the eighteenth century, copper smelting was started in England and the reverberatory-furnace smelting was introduced. Great Britain became an important copper producing country, but with the introduction of electrolytic refining, the industry passed to America—temporarily, it is hoped, for a reason which I shall explain. The recovery of copper from its ores has undergone modifications and improvements, so that ores containing 3·5% copper and even less can be economically and profitably smelted after concentration by one of the many flotation processes. The enormous deposits of copper ores which have been discovered in Africa, especially in Rhodesia, *may result in the British Empire becoming the most* important copper producer in the world. This copper is of a particularly high grade of purity.

Copper used for electrical purposes must have a very high degree of purity, since the electrical conductivity is extremely sensitive to the influence of impurities. H.C. copper of good average quality will contain 99·92%—99·96% copper, 0·03%—0·05% oxygen, and less than 0·02% of other impurities. All these impurities have an effect upon copper, and during the past few years our knowledge of the effect of small amounts of impurities on the properties of copper has been greatly extended. Research was started in about 1924 by the British Non-Ferrous Metals Research Association on the "Influence of Impurities up to 1·0% on the Properties of Copper," and several important reports have been issued, the conclusions from which form a reasonably firm basis of our knowledge and use of copper.

The work was carried out at the National Physical Laboratory under the direction of Rosenhain, and the reports are models in the way of presentation of results.

The properties of outstanding importance to the distribution of electrical energy are conductivity,

* Read before the Liverpool Section, on April 7, 1933.

sufficient mechanical strength, and resistance to atmospheric and other corrosion. If the two metals used in distribution of electrical energy, viz. copper and aluminium, are compared, it will be seen that although both metals have high conductivities, aluminium is considerably poorer as a conductor of electricity than copper, but has the advantage of being lighter in weight, so that its use leads to several economies.

Unlike copper, aluminium was only discovered as a metal in 1822 by Wöhler, who isolated it by the interaction of potassium on aluminium chloride. It was not until Héroult, Hall, and Cowper Coles developed the electric furnace for the electrolysis of fused electrolytes that aluminium became of commercial importance.

Again, unlike copper, which is refined after extraction from the ore, aluminium ores are purified before the metal is isolated from them, and the metal at present is incapable of being refined.

These two dissimilar metals are associated together in the distribution of the greatest form of energy entrusted to mankind, and one feels that unless some epoch-making discovery renders it possible to utilize the ether of space for distributing electrical energy, we shall have to make the best of these two metals for a long time to come.

The third metal, lead, owes its association with the other two to its peculiar properties of flexibility and ductility which enable it to be extruded as a pipe, and to its power of withstanding corrosive agents to a remarkable degree. The covering of insulated copper or other conductors with a lead sheath to keep the insulation dry and free from external influences is a common practice, and one which, owing to the unique properties of lead, it seems difficult if not impossible to replace.

In passing, it may be pointed out that lead is now refined electrolytically and is produced commercially in a very high degree of purity. It can be purchased with a purity of 99·997%, only the most refined methods of chemical analysis and the spectrograph being capable of detecting the impurities.

The production of such high-grade lead is a triumph of modern metallurgy, but its uses at first brought about certain difficulties which will be described later. For the protection of insulated conductors, pure lead or alloys containing lead, as a major constituent, and small amounts of tin, antimony, and cadmium may be used. It is seldom that more than two of these metals are added to lead for sheathing alloys. By the use of either binary or ternary alloys a stronger sheath is obtained; in some cases the alloy is more resistant to corrosion than plain lead, and what is even more important, has the power of resisting failure to which lead is liable under vibration.

The more detailed discussion of the properties and uses of these three metals reveals a number of vital and important properties, also a number of limitations. The extraction of copper from ores and its refining have undergone many important improvements. The old methods involving seven to eleven furnace operations have been reduced to comparatively few simple operations, and whereas the older methods required rich ores containing 30% and more of copper, modern processes can utilize low-grade ores containing 3·5%.

In outline, the modern method of extracting copper from its ores comprises: (i) Crushing the ore: (ii) Concentration of the copper from the crushed ore by a flotation process whereby the percentage of copper is increased from 3·5% to 55—56%; (iii) Smelting the concentrates to matt of purified copper sulphide plus a certain amount of iron sulphide in a reverberatory furnace: (iv) The conversion of the matt into blister copper in a converter. The difference between the copper converter and the steel converter lies chiefly in the fact that whereas the blast of air in the Bessemer converter is blown through the molten metal, in the case of copper it is only blown through the matt, and the copper collects below the level at which the blast is introduced; (v) Refining the blister copper by (*a*) fire refining, (*b*) electrolytic refining.

The choice of the refining process depends upon the impurities present in the blister copper. Electrolytic refining has great advantages, especially if the blister copper contains silver and gold, which are recovered from the anode mud, or if it contains metals which are not removed by other processes. As a result of electrolytic refining, copper has been produced commercially in large quantities, in a high state of purity, having a high electrical conductivity. High conductivity copper was demanded for conductors and general electrical purposes, and is used for stranded conductors which are insulated with material such as rubber, oil-paper, and are protected externally in a variety of ways or it is used in the form of single strands which are left bare for overhead systems of trams and railways. Insulated strands are usually soft annealed copper while the bare wires are hard drawn and possess relatively high tensile strength.

When copper is exposed to air it undergoes certai changes dependent upon the surrounding atmosphere In sulphur-laden atmospheres, copper sulphide is forme and it becomes blackened. In salt-laden air it develop a green colour, and in clean country air, it often develop a beautiful green "patina," which is seen on copper covered roofs and church towers, especially on th Continent. Attempts have recently been made to repro duce this artificially, but there seems a great advantag in the slow, natural formation. It is easy to form thes colours fairly rapidly, but when formed rapidly the readily disintegrate and fall off, with the alternatin expansion and contraction due to temperature change

In the chemical-laden atmosphere of manufacturin towns extensive corrosion of the bare copper tak place. Bare copper conductors in the foul atmosphe of tunnels through which steam locomotives pass, corro badly. Various copper salts are formed, but chief copper sulphate. The bad conditions causing corrosi to copper are well recognized, and the copper is eith protected against these conditions, or is systematical inspected and replaced before the corrosion reaches danger point.

An extremely troublesome form of fracture of ove head lines, whether made of copper or aluminium, the fatigue failure. With a line suspended at poin whose distance apart depends upon the strength the wire and also upon the tension and sag of the lin there is a transition from a freely swinging line to

ıtively rigid point, so that vibration stresses are pped and reversed at these points of suspension. · copper and aluminium undergo certain physical nges, resulting in a clean fracture taking place ough the crystal boundaries of the metals, owing the failure of the material or forces which hold the tal crystals together.

\ similar trouble in the case of lead has recently been estigated and explained. This will be dealt with ler lead, as it forms a very important property, which st not be lost sight of when the use of lead for any pose is considered. One of the metallurgist's st difficult problems to-day is to produce a given tal in the best physical condition for the purpose its use. There are two distinct sections of this blem, the working of the pure metal and the use alloys containing the metal as a major constituent. long as the highest possible conductivity is required, oys are excluded, and then the problem narrows down the production of the best physical condition by licious mechanical treatment, including heat treatnt. It is by no means easy to devise a series of ts which will show that the metal is worked so as to e the best results. The tensile strength or ultimate ess may be high and the metal fatigued to such an ent that a break occurs under a very moderate load. is customary to test sheet by additional properties, h as Ericcson's cupping test. Wire and rod are ted by twisting and wrapping, in addition to tensile ts. Brinell hardness forms a useful guide on working blems, but it is of the greatest importance that any t result should be the mean of several individual terminations, and not based upon a single result.

It is difficult to say what are the inherent defects a metal which subsequently cause trouble. Some the causes of unsoundness in the bar or slab are ognized: it is, for many reasons, by no means easy cast a perfect bar or slab of copper. The mould nperature and mould dressing both influence the rface of the metal in contact with the mould, and y even produce unsoundness. The absorption of s by the molten metal, (and in this connexion electric elting seems to he greatly superior to melting with lid or other fuel), causes blowholes and porosity, all which show up when the metal is rolled or drawn. ere is also, with copper, the peculiar condition of . In melting copper it becomes oxidized, and oxygen s to be reduced to between 0·03% and 0·06% before is cast into bars or slabs for subsequent working.

One sometimes hears of the wonderful castings free om all blemishes which were made by the earlier etal workers, and it is refreshing to find evidence at they too had their troubles similar to ours. In e church of the interesting town of Tideswell in rhyshire there is a bell, which is a splendid example 15th century founding, but there is a blowhole on e lip of the bell big enough to hold a walnut.

The introduction of the Durville casting process and e device of double melting result in sounder cast etal. The metal is melted and when molten is owed to solidify. At the moment of solidificaon, dissolved gases are liberated from solution. ie temperature is then raised until the metal is molten once more. This remedy seems applicable to most metals, but it is not too easy to carry out on the large scale. The introduction of water cooler moulds has made a big advance in casting technique, but the large amount of money locked up in moulds when this method is used, makes the general adoption of the system somewhat slow. When a cast metal is rolled or drawn, the defects in the casting must go somewhere. Every casting contains some defects, such as small blowholes in the body of the metal, irregularities on the surfaces in contact with the mould, and in the case of a copper wire bar cast in the open mould there is the "set" surface. It is a matter of dispute as to the fate of these blemishes. Do they disappear, or do they remain and cause bad surface sheet or wire, or internal defects? These questions have not received complete answers, but every producer of metals, be it copper, aluminium, brass or other metal, is striving to remove the defects in the cast metal and produce perfect bars or slabs.

Turning attention to the question of the effect of impurities on the properties of copper and aluminium, there emerges the fact of the very high purity of these two metals as met with commercially. Copper is available in large quantities with total impurities of less than 0·02%. Thanks to the splendid researches carried out by the British Non-Ferrous Metals Research Association, the effects of a large number of impurities on the properties of copper are now known and understood, and the advantage or disadvantage of each impurity can be considered for any projected use of the copper.

The effect of each impurity has been investigated individually, and also in association with the other constituents. One of the most important things that has emerged from that important work is the fact of the influence of one impurity upon another. For example, the effect of arsenic on copper is very different from the effect of arsenic on copper containing oxygen. Further, the effect of arsenic on copper containing oxygen is very different again from that on copper which is associated with traces of nickel and perhaps antimony. When this work is complete it will be classic in the history of copper. So far as electrical uses of copper are concerned, the conductivity forms a safeguard of purity. Very small quantities of additional metals lower the conductivity to a degree which renders it unsuitable for conductors. This was investigated hy Matthiesen and led to the standard of conductivity. It is a remarkable fact that in no case does the conductivity increase when alloys are made from the pure metals. Although silver has a higher conductivity than copper, the addition of silver to copper rapidly lowers the conductivity to a very low value. I believe there is on record a patent held by a prominent professor for increasing condnctivity by adding silver. It is an example of these things which look as though they should work, but do not do so when put to the test.

Space will not permit of a discussion of the effects of the impurities so far investigated, but in general it might be pointed out that an amount of one impurity which would be fatal to the working properties of copper becomes much less injurious and even harmless when

certain other impurities are present. The application of this remedy is limited, since the point is soon reached when the conductivity is reduced to too low a value for electrical work.

The only serious competitor to copper as a conductor is aluminium. It is nearest in conductivity to copper. If the conductivity of copper is taken as 100, that of aluminium is about 60. Further, the density of copper is 8·9, and that of aluminium is 2·7. It follows that weight for weight aluminium is a very good proposition for use as a conductor.

Extensive use of aluminium has been made on the Grid System now almost complete and ready for work. The use of aluminium for this work has led to a great number of problems, but the properties of aluminium have enabled longer spans and lighter towers to be used. The conductors are steel cored aluminium, the steel being used for reinforcing the aluminium strand. The aluminium is the chief current carrier, and the iron takes a small quantity of current, but mainly contributes its quota to the strength of the line. Joints are mechanical joints owing to the impossibility of soldering or brazing aluminium, and the problem of jointing was only one of many which arose during the use of aluminium as a conductor.

In spite of many excellent properties, aluminium is liable to corrosion under certain conditions. The position of aluminium in the voltaic series indicates the possibility of corrosion taking place, if it is in contact with other metals, and the further they are from aluminium in the series, the more rapid and serious is the corrosion. It is of importance to avoid contact of aluminium and other metals, or if they have to come into contact, to exclude air and moisture by painting over the junction with some material, such as bituminous paint, thereby avoiding the formation of a galvanic cell. When exposed to the atmosphere, aluminium behaves differently in different atmospheres. In the sulphur-laden atmospheres of railway tunnels where steam locomotives are in use, corrosion takes place rapidly with the formation of basic aluminium sulphate. In manufacturing towns it becomes rapidly blackened and the amount of corrosion is slight, unless some strong corrosive agent such as chlorine is present, as in chemical towns. In the open country the corrosion is trifling: as a rule a white film of aluminium oxide is formed on the surface, which is protective and the corrosion is retarded, if not stayed.

The highly pure aluminium now produced does not corrode to anything like the extent that the less pure metal of the past did. The addition of other substances to aluminium to reduce its corrosion has the effect of lowering the conductivity and so far as its use as a conductor is concerned, it is doubtful whether the gain in corrosion resistance is sufficient to compensate for the loss in conductivity.

Aluminium was very nearly damned by its friends in the early days of its use when its colour and lightness blinded its advocates to its disadvantages. The use, by a French expeditionary force in Africa, of aluminium of doubtful purity for water bottles, nearly resulted in the loss of the whole force owing to the corrosion of the aluminium being so rapid that the bottles soon leaked. The use of a non-homogeneous aluminium copper alloy for naval boats, destroyers, resulted in the sinking of a number of vessels. In this case rapid corrosion took place owing to local electrolytic action between the two dissimilar metals. Since that time the problem of corrosion of most metals has been very completely investigated and a technique developed for the examination of metals and alloys prior to their use, so that the behaviour of the metal under given conditions can be predicted with a fair approximation to the truth.

It is now necessary to turn to the third metal of this group. Lead is by no means the least important member of the three, but it differs greatly from the other two. Its use is mainly protective, being used to protect insulation from water and damage, and in the case of those cables which consist of oil-impregnated dielectrics it serves to retain the oil. Like the other two metals lead has its peculiarities which show up under conditions favourable to their development. It has enormous uses as a base for paints, as white lead, and oxides of lead. Traces of impurities have a profound influence on the rate of corrosion, *i.e.*, conversion into basic carbonate or oxide, and upon the colour of the products. These impurities also bring about other changes in properties which are of considerable interest to the present aspect of its use.

The corrosion of metals by strong acids is often anomalous. The ease with which aluminium is attacked by hydrochloric acid is in sharp contrast to its resistance to attack by nitric acid. Lead withstands the attack of sulphuric acid with considerable resistance, but it is readily corroded by weak organic acids, and if carbon dioxide is present, the lead is rapidly converted into basic lead carbonate. It is by no means infrequent to find lead corroded when buried in soil containing decaying organic matter, such as peat, vegetable matter, or drainage from manure or sewage. In such cases the conditions simulate the old Dutch process for the production of lead carbonate or white lead, in which process gratings of lead were put over pans containing a little dilute vinegar, and then surrounded with decaying tan bark. The decaying tan bark produced a certain degree of warmth, the acetic acid from the vinegar attacked the lead, forming lead acetate, and the CO_2 from the fermenting tan bark converted the lead acetate into lead carbonate, regenerating the acetic acid. Very serious cases of this type of corrosion have been encountered from time to time, and it is worth while to make an examination of the soil before any lead is buried in it.

In these days of extensive electrification, leakage or vagabond currents are frequently encountered. These currents find their way in and out of lead-covered cable sheathing. They leave the lead for the soil where the resistance conditions are favourable and pass into the lead again at some other point, where lead is a better conductor than the soil. The product of the corrosion is the formation of lead peroxide, and the presence of lead peroxide can be taken as a proof of electrolytic corrosion. Its absence, however, does not exclude that possibility, since reaction may have taken place between the lead peroxide and the soil constituents, resulting in the formation of basic lead carbonate, which is by far the

..ost general corrosion product. The danger of electro-..tic corrosion is provided against by making an ..ectrical survey of the route in which the lead covered ..ble or other object is to be laid. Suitable earthing ..ints are then provided, so that the current leaves ..e sheathing at known and definite points, via the so-..lled earth plates. This procedure is advisable when ..ad or other metals have to be buried in the neighbour-..ood of existing electrical undertakings.

An interesting form of failure has been investigated ..d counteracted, again through the British Non-F..rous Metals Research Association. It was observed ..hat when lead was exposed to vibration, such as when ..uspended overhead, or where it is passed from a railway ..ank to a bridge or platform, it underwent a curious and ..haracteristic form of cracking. In appearance it looked as though the lead had crystallized into a collection of ..oose crystals, or like a brick wall when mortar has ..ropped out. The appearance of the lead is very ..haracteristic. A gap occurs in the pipe or sheet, the ..orders of which are collections of loose cubic crystals of varying size. The trouble always starts from the inside of a cable sheath, and is visible in its initial stages before it has caused the gap to form.

This trouble was encountered at intervals when cables were suspended overhead, or when they were laid in positions where they were subjected to vibration, due to passing traffic. The cracking was evidently due to vibration, but the real explanation and remedy were not available until the completion of the researches already referred to above.

The introduction of the high purity electrolytic lead brought a crop of unexpected failures. A shipment of lead sheet arrived at its destination showing evidences of intercrystalline failure. Consignments of lead-covered cables arrived with rents in the sheathing, several inches in length. As this happened to several different consignments, the condition was alarming. It should however be made clear that these failures were due to excessive vibration caused by improper storage on the vessel. Still they were alarming failures, and the old question "Why did it not happen before?" was a difficult one to answer. The business board were quite unable to understand the physical failure of lead under the conditions to which they had been subjected. They preferred to believe that it was "Burnt Lead," what-..er that may be, and would have readily believed ..ut if it could be shown that lead contained 0·000002% ..f Polonium, the failure was due to it. In the mean-..me evidence had been accumulating that high-purity ..ad was more prone to this type of failure. A frequent ..mplaint from those melting the lead was that it was "..irty lead," meaning that it readily oxidized when ..olten.

A machine was then developed by Prof. B. P. ..aig of Woolwich for testing the fatigue-resisting ..operties of metals, and in this machine the lead ..r other metal could be subjected to alternating ..resses. It was shown that pure lead failed under ..is test much more rapidly than less pure lead ..r alloys of lead, and the mechanism of the ..ilure was cleared up to a very large extent. The remedy was clearly the use of alloys instead of pure lead in situations where it would be subjected to vibration or better, to alternating stresses. This type of failure is common on ships, especially on boats driven by high-speed turbines, where the vibration is of short wave length and may not be so perceptible by the feeling of discomfort as vibrations of longer wave length. Special steps are taken to combat the failure on ships, and a number of alloys of lead have been developed whose fatigue resistance is very much greater than lead.

The question might be asked "Are we getting the best possible out of these metals for the purposes under consideration?" A fair answer is "Yes, in the present state of knowledge and the art of metal working."

Thanks to intensive research which is going on, new knowledge is rapidly becoming available, and thanks to the Institute of Metals, The British Non-Ferrous Metals Research Association, and similar institutions, our knowledge of metals has been enormously increased and is being increased.

The effects of both hot and cold work on metals, the influence of impurities, annealing, changes in properties when alloyed with other metals, atmospheric tarnishing, corrosion by various agents, all are being investigated. The improved technique of casting, improved moulds and their effects on the properties of the metals are not the least important lines of investigation. A few years ago the properties of metals occupied only a few lines in the various text books on metallurgy. To-day we have volumes dealing with each single metal, and even with some property of one metal.

In view of the rapid increase of knowledge of metals, it would be rash to attempt to prophesy the future progress. A degree of perfection is demanded to-day in purity, quality of metal, and properties, which was only attainable under laboratory conditions a decade or so ago, and the indications are that the striving towards perfection will be as successful in the future as it has been in the past.

THE DEHYDROGENATION OF CHOLESTEROL

By J. W. COOK and C. L. HEWETT

When the structure of a hydrogenated chrysene ring-system was proposed for the sterols and bile acids by Rosenheim and King,[1] exception was taken to it by one of us[2] on the ground that it failed to account for the properties of the two hydrocarbons obtained by Diels, Gädke, and Körding[3] by dehydrogenating cholesterol with selenium. This objection was removed with the introduction of the modified chrysene structure by Wieland and Dane,[4] and the wealth of experimental material which has emerged from the Munich and Göttingen laboratories during the past year has made it abundantly clear that this modified structure must be correct in its essential features. There was, however, no direct experimental proof of the presence of a substituted phenanthrene ring-system in the sterols and bile acids

[1] Rosenheim and King, Chem. and Ind., May 27, 1932, 464.
[2] Kennaway and Cook, Chem. and Ind., June 10, 1932, 521.
[3] Diels, Gädke, and Körding, Annalen, 1927, 459, 1.
[4] Wieland and Dane, Z. Physiol. Chem., 1932, 210, 268. See also Rosenheim and King, Chem. and Ind., Nov. 18, 1932, 954.

until the recent isolation by Butenandt[5] of 1 : 2-dimethylphenanthrene from the products of selenium dehydrogenation of actiobilianic acid.

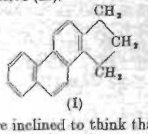
The structure of cholesterol must be such as to provide a rational explanation of its dehydrogenation to the two hydrocarbons of Diels, "$C_{18}H_{16}$" and "$C_{25}H_{24}$," so that a knowledge of their structures is of importance. We have been able to isolate both of these hydrocarbons by dehydrogenating cholesteryl chloride in the manner described by Diels. With regard to the higher melting substance (m.p. 221—222·5°; bright red molecular compound, m.p. 239—240°, with 2 : 7-dinitroanthraquinone) *we may say at once that we agree entirely with* the structure ($C_{25}H_{22}$) recently suggested for this hydrocarbon by Rosenheim and King,[6] and we are seeking confirmation by synthesis. If the lower-melting hydrocarbon were correctly represented as $C_{18}H_{16}$, then it should be a methyl derivative of 1 : 2-*cyclo*pentenophenanthrene, a conception which makes it necessary to postulate migration of a methyl group during dehydrogenation. We were more inclined to the view that the substance was really the unsubstituted hydrocarbon, $C_{17}H_{14}$. Although we carried out the dehydrogenation several times, and obtained a hydrocarbon of which the properties were in general agreement with those given by Diels for "$C_{18}H_{16}$" we were never *satisfied that we were dealing with a pure compound.*

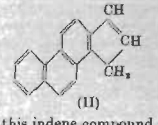
We have now synthesized 1 : 2-*cyclo*pentenophenanthrene (I) and compared it with the dehydrogenation product, "$C_{18}H_{16}$," of cholesterol. The results of melting point determinations are given in the following table:

Compound	"$C_{18}H_{16}$" from *cholesterol*	1 : 2-*cyclo-* *Penteno-* phenanthrene	*Mixed* m.p.
Hydrocarbon ...	*122—124°	152—153°	132—142°
Picrate ...	†120·5—121·5°	133—134·5°	123—126°
s. Trinitrobenzene compound	‡147—149°	165·5—166·5°	153—158°

* Diels gives 123—124°
† Diels gives 117—118°
‡ Ruzicka gives 147—148°

We think, therefore, that it will be conceded that the hydrocarbon from cholesterol (the same substance is obtainable from ergosterol and cholic acid) has been identified as a very impure specimen of 1 : 2-*cyclo*pentenophenanthrene. It is a matter of no surprise to those accustomed to dealing with the higher aromatic hydrocarbons that the removal of the contaminating impurities should present such very great difficulty. A good example of this (and many others might be cited) was furnished by one of us[7] in the case of 6-isopropyl-1 : 2-benzanthracene. From our sample of the trinitrobenzene complex of the cholesterol hydrocarbon we recovered, by reduction with tin and hydrochloric acid, a substance which was found to have a melting point *ca.* 150°, but was not completely liquid below 163°. The melting point was not depressed by pure 1 : 2-*cyclo*pentenophenanthrene. This experiment confirms the heterogeneous character of the Diels hydrocarbon. The nature of the persistent impurity in the hydrocarbon from cholesterol is somewhat problematical, but *we suggest that it may be the corresponding indene* derivative (II).


(I)


(II)

We are inclined to think that this indene compound (II) was the hydrocarbon, m.p. 239—240°, isolated by Ruzicka and Thomann[8] as a product of selenium dehydrogenation of cholic acid, and that this is identical with the hydrocarbon, m.p. 243°, obtained by Butenandt[9] from ketohydroxy-œstrin by zinc dust distillation.

The absorption curve of 1 : 2-*cyclo*pentenophenanthrene has been compared with that of the hydrocarbon from cholesterol (*cf.* Rosenheim and King[6]), and in the region of the spectrum so far examined the absorption curves are identical. We are indebted to Miss Roe, B.Sc., for these observations. A larger supply of 1 : 2-*cyclo*pentenophenanthrene is now being prepared for more complete chemical and physical examination.

When we decided to undertake the synthesis of 1 : 2-*cyclo*pentenophenanthrene we realized the need for a new general method of synthesis of complex compounds containing the phenanthrene ring-system. We have been able to devise a method which promises to be of very wide application for the production of condensed hydrocarbons of phenanthrene and fluorene type. This method, *which will be fully described* elsewhere, *consists essentially in the cyclization of an* aromatic compound containing an unsaturated side-chain. It has enabled us to obtain 1 : 2-*cyclo*pentenophenanthrene with remarkable facility, and serves for the production not only of aromatic ring-systems, but also of hydroaromatic ring-systems. For example, we obtained 1 : 2 : 3 : 4 : 9 : 10 : 11 : 12-octahydrophenanthrene as an intermediate product in the synthesis of phenanthrene. The new method may also be utilized for the synthesis of homologues, including those with γ-methyl groups, and will therefore be of service in the synthesis of compounds of the sterol, bile acid and œstrin groups. 1 : 2-*cyclo*Pentenophenanthrene is the first synthetic compound containing the complete ring-system of these substances.

The Research Institute of the Cancer Hospital (Free), London, S.W.3

[5] Butenandt, Weidlich and Thompson, Chem. and Ind., Mar. 31, 1933, 289.
[6] Rosenheim and King, Chem. and Ind., April 7, 1933, 301.
[7] Cook, J. Chem. Soc., 1932, 456.
[8] Ruzicka and Thomann, Helv. Chim. Acta, 1933, 16, 224.
[9] Butenandt, Angew. Chem., 1932, 45, 655.

DR. HUGH STOTT TAYLOR

Dr. H. S. Taylor, who was recently awarded the Mendel Medal of Villanova College in America, is well known as a chemist not only in America, where he is chairman of the chemistry department of Princeton University, but in many other parts of the world. The Mendel Medal was established four years ago to commemorate the biological work of Gregor Mendel, and its award to Dr. Taylor marks a further appreciation of his work in promoting the cause of science.

Although he joined the staff of Princeton University in 1914, Dr. Taylor is English by birth, and his training was received at the University of Liverpool. He became professor of physical chemistry at Princeton in 1922 and chairman of the chemistry department four years later. The following year he was appointed David B. Jones Professor of Research Chemistry at the University. His work at Princeton, notable as it is, represents only a part of his activities, for he is a member of several scientific societies and has taken a prominent part in their affairs, whilst he has achieved much distinction as a writer on scientific matters. He is at present an associate editor of the American Chemical Society, of which Society he was the Nichols Medallist in 1928. He is the joint author with Dr. E. K. Rideal, of

"Catalysis in Theory and Practice," and the editor of a "Treatise on Physical Chemistry," now in its second edition, besides having contributed alone or in collaboration with others, more than 100 papers on catalysis and the mechanism of chemical reactions to American and European scientific journals.

The National Research Council of America is indebted to him for a very large amount of work: he is chairman of its committees dealing with photochemistry and petroleum, and a member of the committee on contact catalysis, and is associated also with the Research Fellowship Board of the Textile Foundation. In 1932 he was elected to a Fellowship of the Royal Society in this country, and is visiting England shortly to be formally admitted. England will welcome the return, if only for a short time, of so distinguished a scientist.

CANNON IRON FOUNDRIES, LTD.

In 1926 Cannon Iron Foundries, Ltd. celebrated its centenary. The celebration appears to have been carried out with no half measures, and will, we imagine, be remembered in Deepfields for many years. The firm was not always called by the well-known Cannon name; in 1826 it took the name of its founder, Edward Sheldon, and continued with it for nearly sixty years, when it became the Cannon Hollow-ware Co. With the coming of a new century it seems that the firm thought it desirable to get "off the mark" with a name more suited to its risen status, for by that time it had passed well beyond the "pot and pan" stage, and so in 1900 the firm became known by its present title. Pots and pans were however the beginning of this firm, which is now one of the biggest manufacturers of chemical plant. It is somewhat strange to think that in those early days England was dependent on foreign production even of pots and pans. The records have it to the credit of Edward Sheldon that he brought the business to England, and here it stayed, until a few years later a substantial export business had been built up. An advertisement of the firm used in 1841 has a quaint ring about it: it speaks of Marmont and Negro pots, waffle irons, wrought-iron money chests, cast-iron bookcases, and patent kitchen furniture. The "modern" metal furnishing is perhaps not so modern, although the cast-iron bookcase sounds a trifle more substantial than anything produced nowadays.

In those early days the premises covered half an acre, and the employees numbered less than twenty. Both have now multiplied fifty-fold. Recently we had the pleasure of visiting the works at Deepfields, on the outskirts of Wolverhampton, and of seeing how far the firm's productions have developed from the original pots and pans. The firm's name, it seemed, is a good one; extensive foundries there were, making every type of casting from straightforward distillation pans to complicated cast "nests" of tubes for condensers; using wooden patterns, iron patterns, with here and there examples of "striking out" such as have always made the foundryman's craft seem to us more of an art than seems generally to be appreciated. The products of the firm are many and diverse, and it would take an article much longer than this to touch on them all, much less treat them adequately. The chemical industry finds the Cannon Foundries principally of interest for its production of autoclaves, evaporating and distillation pans, boilers, condensers, etc. In the various shops of the factory we saw the castings being machined, finished, and assembled, but probably the most interesting workshop was that in which the dry process of enamelling was being operated. During recent years the firm has become famous for its acid-resisting enamelled ware; it is indeed one of the few concerns in this country producing this type of plant, which is of special interest to the manufacturer of pharmaceutical and fine chemicals, the manufacturer concerned with food processing, and others who must ensure that their products are not contaminated by the vessels in which they are treated. We visited the enamelling shop at the right moment to see some pans being drawn glowing from a muffle furnace, to be rotated quickly whilst the siliceous dust was applied, and then replaced in the muffle for the final process of fusing.

In this part of the works one finds an old member of the Society, Mr. H. B. Stewart, supervising the enamelling of chemical plant, and ready to talk of the problems of his specialized job. Enamelling has had many such problems to surmount and in a laboratory here many of them have been brought to a successful end-point.

It is of interest to note that there is in the Cannon works one of the biggest muffle furnaces in England, but this is only one indication of the endeavours made by the firm to place itself in the position to be able to undertake work of every possible size and scope. The new buildings erected a few years ago provide a model of the best features in modern industrial building practice. In them everything is well-lit, plenty of space is provided for every operation, and travelling cranes, muffle furnaces, etc. are electrically operated. One of the biggest departments of the works to-day is that concerned with the manufacture of gas-heating apparatus. Gas cookers and heating units are produced in thousands, and the average householder would probably be very much surprised to know the thoroughness and multiplicity of the tests to which such heaters are subjected. In this part of the works the wet-spraying process of enamelling is employed, a sound and rapid method that has been developed to give some attractive effects.

Some of the most notable industrial undertakings in this country have been for many years under the control

VIEW OF THE GENERAL FITTING SHOP

of members of particular families, and the Cannon works is an example of the benefit to be obtained from continuity of control through succeeding generations. Mr. R. Talbot Clayton, the present managing director, is a descendant of the founder of the firm, and the grandson of Mr. R. Clayton, who started the manufacture of gas cookers and heating stoves in 1895. The other members of the directorate are Mr. R. Douglas Clayton and Mr. F. E. Sheldon Clayton, brothers of the managing director, and Mr. W. E. Hawthorne. There is thus a continuous link with the Sheldons during the passing of the last 100 years. If such continuity of control is all to the good of an industry, the good work of employees is no less important. One of the best indications of the good work of employees is to be found in the records of their long service; such records as are to be found at the Cannon works would, we think, be hard to match. Thus a firm can rarely claim to have on its staff a dozen men with a total of over 500 years' service between them, as was the record of the Cannon Foundries in its centenary year. But the works can do even better than the staff office: Here, it seems, any man with less than forty years' service must be regarded as rather a promising youngster: for in 1926 there were seven men with more than fifty years' service each, and thirty who had been in the foundries for over forty years, whilst we imagine that one, Benjamin Norton, must have been scornful of them all, for he had it to his credit that he was "for 71 years a loyal and faithful servant of the company."

SOCIETY OF CHEMICAL INDUSTRY

OFFICIAL NOTICES

Annual General Meeting. This week's Calendar of Forthcoming Events (p. vi) contains the programme of the Annual Meeting at Newcastle from July 10-14 which will be posted in full detail to members shortly. From this it will be seen that the title of the Presidential Address will be "The Industrial Use of Textiles," and that on the occasion of his receiving the Society's Medal Prof. W. A. Bone will lecture on "Forty Years of Combustion Research." The titles of other papers to be read are given and also details relating to visits to works. Mr. B. P. Hill with the co-operation of several firms will arrange an exhibition in one of the College laboratories. It is hoped that the privileges of the University Union will be available for members during the week.

Election of Members of Council. The last day for nominating members for election to the four vacancies on the Council is June 5. Nominations must be made on the proper form B and must be signed by the candidate and at least five members who have not signed another nomination paper.

Beilby Memorial Awards. Members are reminded that the last day appointed for receiving nominations is June 1 next.

Food Group. The arrangements for the annual general meeting on Friday, May 26, at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1, are as follows:

4.45 p.m.—Tea by invitation of the Metropolitan Branch of the Society of Medical Officers of Health.

5.0 p.m.—Joint Meeting with above Branch. "The Prevention of Industrial Diseases of the Skin," by Dr. Haldin-Davis, followed by discussion to be opened by Dr. Howard Mummery.

6.30 p.m.—Business of the Annual General Meeting. (approx.)

7.0 p.m.—Cinematograph Film "From Orchard to (approx.) Home." Chivers.

The Group is taking charge, under the chairmanship of Dr. L. H. Lampitt, of Section "F," Hygiene of Food, at the Annual Congress of the Royal Sanitary Institute at Blackpool in June.

The Group's session begins at 10 a.m. on Wednesday, June 21, in the Winter Gardens.

A sessional ticket will be sent to every member of the Food Group and must be signed by him before presentation.

Other members of the Society desiring to attend the session should apply direct to Dr. J. W. Dudley Robinson, The Royal Sanitary Institute, 90, Buckingham Palace Road, S.W.1, to whom application should also be made by all wishing to secure vouchers for reduced railway fares.

The session will take the form of a joint discussion on *the wrapping of bread and of butter.* The main contributors will be:

Dr. C. J. J. Fox of Messrs. Cross & Bevan; Mr. C. H. F. Fuller of the Research Department, J. Lyons & Co., Ltd.; Mr. P. Arup, Butter Testing Station, Department of Agriculture, Dublin; Dr. G. H. Dart, Medical Officer of Health, Hackney.

Invitation to Shipping, Engineering, and Machinery Exhibition. The organizers of the Shipping, Engineering, and Machinery Exhibition to be held at Olympia from September 7 to 23 will shortly invite all members of the Society to visit the Exhibition on Saturday, September 16, and to tea during the afternoon. Early intimation is given so that members may book the date and the individual invitations will be issued by post in due course. Members of Council will also receive an invitation to lunch on the same occasion.

MONTREAL SECTION

The annual general meeting of the Montreal Section of the Society was held on April 27, with the chairman of the Section, Dr. O. Maass, presiding. Dr. Maass reported successful activities of the Section during the year. Lectures had been extremely well attended, and visits had been made to Canadian Industries, Ltd., at Beloeil and the Distillers Corporation at Ville St. Pierre.

The following officers were elected for the years 1933—34: *Chairman:* Mr. R. A. Witherspoon; *Hon. Secretary:* Mr. M. C. CollMcFee; *Treasurer:* Mr. J. S. Rovey; *Committee:* Dr. O. Maass (retiring chairman), Dr. W. H. Hatcher, Prof. Nadeau, Dr. S. G. Lipsett, and Messrs. C. M. Skinner, R. T. Walley, P. Bromilow, and P. Lebel. Thanks were given by the Section to the retiring chairman, Dr. Maass, and to the honorary secretary, Mr. M. C. CollMcFee for their able work during the last year. Four delegates were appointed to the Canadian Chemical Association as follows: Dr. O. Maass, and Messrs. D. Lorimer, T. W. Smith, and R. A. Witherspoon.

It was announced by the chairman that the bursary of $50 offered by the Section had been awarded to Mr. H. E. Chalk, chemical engineering student of McGill University, for his paper on "Pulp Fibre Classification by Selective Screening."

THE ROYAL SOCIETY

The first of this year's Conversazioni of the Royal Society was held at Burlington House on May 17. The following were amongst the exhibits. Messrs. Imperial Chemical Industries (Alkali), Ltd. showed apparatus for carrying out chemical reactions at pressures up to 12,000 atm. at temperatures up to 200° C. An exhibit of oriented overgrowths in crystals showed the effect of one substance, *e.g.*, sodium nitrate, on the growth of crystals of another substance, *e.g.*, calcite. When crystals of the two substances have approximately the same atomic spacings on a crystal face, these faces, in crystal growth, will adhere to one another. A greaseless valve, in which motion of a platinum rod relative to its seating was controlled by compression or extension of a series of glass bulbs, was also shown. The Gas Light & Coke Co. had an exhibit illustrating the crystallization of ammonium sulphate, and the effect of added impurities on its habit. The presence of 0·003% of iron in the crystallizing solution causes the crystals to assume a long pointed hexagonal form, the pure solution yielding, under exactly similar conditions, compact rhombic crystals. The presence of aluminium, chromium, or beryllium produces similar variations of habit. Owing to the small area of contact between crystals of the long pointed hexagonal type, these crystals have the very desirable property of not caking into hard lumps on storage or during transport. The Brown-Firth Research Laboratories had exhibits illustrating the alternate production and destruction of passivity towards corrosion in a carbon steel, a method of automatic temperature, control for electric furnaces used for "creep" testing showing control to within ± 0·05° C., and plug and ring exhibits illustrating thermal expansion effects on high and low expansion steels, and precision work on a super-hardened steel piston of aluminium-chromium steel. Prof. C. H. Lander, Dr. Margaret Fishenden, and Mr. O. A. Saunders showed how the refraction of light can be used in the measurement of heat transfer in liquids and gases for both stream-line and turbulent conditions. A parallel beam of light at grazing incidence is deflected away from a heated surface because of the temperature gradient normal to the surface. The heat transfer is calculated from the deflexion registered on a suitably placed screen, and for turbulent conditions is found to oscillate about a mean value. The exhibits of Messrs. Adam Hilger, Ltd. comprised the Hilger–Renshaw portable photoelectric apparatus for carrying out clinical blood tests, apparatus for determining the vitamin-*A* content of fish liver oils, the Williams–Rayleigh interference refractometer for measuring exceedingly small differences of refractive index, and specimens of optical work including a large quartz prism built of separate pieces in optical contact, a quadruple lens of fluorite, quartz, and sylvine for use in the ultra-violet, and accurate cells of fused silica constructed without the use of cement. The Rothamsted Experimental Station demonstrated the action of nitrates in preventing the infection of the root-hairs of plants by bacterium radicicola. Infection by this nodule-forming organism always takes place through root-hairs previously deformed by a filterable secretion of the nodule bacteria. The presence of nitrate checks the action of the secretion, thus inhibiting infection, as the bacteria never enter normal root-hairs. The Metropolitan-Vickers Electrical Co. had an exhibit demonstrating the possibilities of high vacuum technique consequent upon the introduction of vacuum oils having vapour pressures about 1/10,000th of that of mercury at the same temperature, and capable of being boiled without decomposition in a suitably designed condensation pump. Greases of negligible vapour pressure at room temperature have also been prepared and these make possible the free use of ground joints in really high vacuum work. An electrical discharge lamp called the

"Osira" lamp, which runs at ordinary mains voltage and starts automatically when switched on, was shown by the General Electric Co. The efficiency of the lamp is high, i.e., 38 lumens per watt, compared with the 15½ lumens per watt given by a tungsten filament gas-filled lamp of similar wattage. So far, the lamp has been applied more especially to street lighting. Messrs. Dewrance & Co. showed a bi-colour water level indicator designed to give a clear indication of the water level in a boiler drum, the water and steam spaces being shown in contrasting colours. Specimens of compounds of 1 : 2 benzpyrene, the fluorescent carcinogenic material recently isolated from pitch, and similar to a product of the reaction between aluminium chloride and tetralin, were shown by the Research Institute of the Cancer Hospital. Drs. N. U. Meldrum and F. J. W. Roughton demonstrated some of the properties of carbonic anhydrase, an enzyme recently isolated from blood. It catalyses both phases of the reversible reaction $CO_2 + H_2O \rightleftharpoons H_2CO_3$. Its use in volumetric titrations was demonstrated. Recent developments in infra-red photography consequent upon the introduction of a new sensitizing dye which makes possible the production of a very rapid photographic plate for use in the infra-red region were described and illustrated by Messrs. Ilford, Ltd. Mr. G. H. Gabb exhibited the "Royal Society Thermometer," the earliest standard thermometer in England, ante-dated only by that of the Academio del Cimento. Its only fixed point, about 88° F., was apparently based on the temperature of the human body, and the low registration of this temperature is probably due to the large bulb used in the construction of the thermometer. Sir Robert Hadfield showed specimens of metallurgical interest, mainly ferrous, including a large series of tensile and other tests at $-252 \cdot 8°$ C. Prof. Bone showed photographs demonstrating the influences of strong electric and magnetic fields upon the phenomenon of "spin" in gaseous detonations. He also demonstrated the striking fact that the explosion of gaseous mixtures of composition $C_2H_2 + O_2 + 2H_2$ in glass bulbs proceeds according to the equation $C_2H_2 + O_2 + 2H_2 = 2CO + 3H_2$, i.e., the acetylene is burnt preferentially to $2CO + H_2$, leaving the original hydrogen intact. R. C. French showed, by electron diffraction analysis, that polishing a metal causes the gradual breakdown of the surface crystals of the metal into smaller and smaller aggregates until the surface is almost amorphous, a result in accord with the views of the late Sir George Beilby. The exhibit by the Cambridge School of Physicists included photographs of tracks of penetrating radiation, positive electron tracks using a neutron source, and the production and detection of neutrons. That we live in a mechanical-electrical age was abundantly demonstrated by the appearance of the Mallock Equation Solving Machine, a device capable of solving, by the mere turning of dials controlling electrical circuits, up to 10 linear simultaneous equations between 10 unknowns. The instrument—it must be seen to be believed—has been constructed by the Cambridge Instrument Co., and has been made possible by the use of mumetal in the transformers employed, together with automatic compensating circuits with valve amplification.

CHEMICAL SOCIETY

An ordinary scientific meeting was held on May 18, the president, Prof. G. T. Morgan, F.R.S., occupying the chair.

Dr. H. W. Thompson discussed :

The Oxidation of Zinc Dimethyl. [With N. S. Kelland.]

The oxidation of zinc methyl vapour has been studied kinetically. At very low pressures there is an extremely rapid oxidation, zinc methyl methoxide being the final product. Thus the process is not a simple oxidation of alkyl groups. At higher pressures an explosive decomposition of the oxygenated products occurs, the principal products in which are carbon monoxide, methane, and hydrogen.

The rate of the measurable reaction is independent of the oxygen concentration and proportional to that of zinc methyl ; it is unaffected by the addition of inert gases and only very slightly increased by increase in temperature. It is not much influenced by vessel dimensions.

For the explosion, there is for any given pressure of zinc methyl a critical pressure of oxygen, and *vice versa*, if the zinc methyl pressure is above a minimum value. The plot of zinc methyl concentration against that of oxygen is displaced to lower values with increasing temperature, or with increase in diameter of the cylindrical reaction vessel. Inert gases affect the critical explosion pressures in a peculiar manner : for any given zinc methyl concentration the requisite oxygen concentration is at first not much changed by the presence of the inert gas, but at higher concentrations of the latter there is a rather sudden increase in the oxygen pressure needed for explosion.

It is suggested that reaction chains are involved. These are formed when active centres of a peroxide nature, formed on the surface, escape into the gas. Under certain conditions the chains may branch and the reaction velocity become infinite. Attention is drawn to the extreme rapidity of the measurable process and its possible analogies with the reactions occurring in the highly diluted flames of Polanyi and his co-workers.

Mr. A. C. G. Egerton said that he was particularly interested in Dr. Thompson's study of the intermediate products formed in the combustion of zinc dimethyl. He had tried the effect of zinc dimethyl with petrol in an engine ; although at first some effect on the knocking appeared to be obtained, that effect was probably spurious, and it is hardly to be expected that the zinc methyl methoxide would survive the engine temperature for long enough to be effective as an anti-knock. On the other hand he was fairly sure that in the case of lead tetraethyl the intermediate peroxide compounds were the important effective agents, for lead ethyl when passed with air through a heated tube formed a stable white substance which could be readily vaporised.

Prof. W. E. Garner said that Dr. Thompson had obtained a very interesting result, in that he had found that inert gases have an inhibiting effect on the production of flame in mixtures of zinc dimethyl and oxygen, commencing at a particular concentration of inert gas. This fact does not, however, agree with the mechanism he has put forward for the reaction. According to this equation the inert gas should commence to

have an effect on the limiting oxygen concentration at the smallest pressures, and not at a particular finite pressure.

Dr. Thompson replied that the expression:

$$\text{reaction rate} = (k_1k_6[\text{ZnMe}_2]^2[\text{O}_2])/(k_5 + k_2 + k_3[\text{O}_2] + k_4[\text{N}_2] - \alpha k_6[\text{ZnMe}_2])$$

becomes infinite and the reaction explosive when the denominator becomes zero, *i.e.*, when α is great enough to make the term $-\alpha k_6[\text{ZnMe}_2]$ adequately negative. The addition of inert gases adds a positive quantity to the denominator and may eventually restore a finite rate. The transition may, moreover, be sharp, the measurable reaction being determined rather by the numerator. This peculiar inert gas effect indeed suggests the presence of a "branching chain" effect.

Mr. H. Robinson discussed:

Explosions of Methane and Air: Propagation through a Restricted Tube. [With R. V. Wheeler.]

The effect on the speed of propagation of flame in mixtures of methane and air, through a tube open at both ends, of closely set restrictions has been studied (see J., 1920, 117, 47; 1926, 2139). The tube was of steel 32·3 m. long and 30·5 cm. in diameter, and the restricting rings, 11 in number and set 30·5 cm. apart, reduced the diameter to 10·2 cm., the first ring being 13·4 m. from the end at which ignition of the mixtnre (9·8 to 10% methane in air) was effected.

The speed of the flame up to the first restricting ring was slow (abont 2 m. per sec.) and nearly uniform; within the restricted zone it reached 450—470 m. per sec.; and beyond the restricted zone it reached 600 m. per sec. after falling to 300 m. per sec. No discontinuity in the combustion within the restricted zone, and no sudden increment in speed of the flame, such as occurs when the detonation wave is initiated, conld be detected; nor was a constant regime comparable with that of detonation wave established beyond the restricted zone, despite the high speed at which the flame travelled.

Photographic records of the passage of flame through and beyond the restricted zoue disclose the production of compression waves reflected back through the burning gases behind the flame-front.

Mr. A. C. G. Egerton said that it was hardly to be expected that methane–air mixtures would detonate; nevertheless it was interesting to have these results of experiments carried out on a large scale. Anyone familiar with measurements of flame velocity would realise the great influence of the tube diameter and shape on the flame velocity; this made it important from the point of view of safety in mines to study these effects in apparatus of large dimensions.

Dr. O. C. de C. Ellis said that the rate at which flame propagates along a tube may undoubtedly be affected by increasing the diameter of the tube; it is quickened in the "uniform movement" and is retarded in the converse mode. In the compartmented system used by the authors, however, the effect of diameter is negligible, the operative factor in this abnormal projection of the flame being undoubtedly the local generation of pressures as illustrated by them.

Dr. J. A. V. Butler discussed:

The Free Energy of the Normal Aliphatic Alcohols in Aqueous Solution. [With D. W. Thomson and W. H. Maclennan.]

A description is given of determinations of the partial free energies of aqueous solutions of methyl, *n*-propyl, and *n*-butyl alcohols, of the mutual miscibility of butyl alcohol and water, and of the solubilities of the normal aliphatic alcohols from C_5 to C_8, at 25°. The free energy of transfer of the alcohols from their pure liquid to dilute aqueous solution has been evaluated, and is found to increase by about 800 calories for each additional $-CH_2$ group after C_2H_5OH. The free energy of transfer of water from the pure liquid to dilute solution in the alcohols increases by amounts which diminish as we pass up the series.

A modified form of Langmuir's theory of solutions is presented and applied to these solutions. It accounts for the main features of the differences between one alcohol and another, and for the variation of the activity coefficients of the lower alcohols with the concentration, except in solutions containing a large proportion of water. In these solutions marked deviations from the equations occur which are attributed either to orientation of the water round the alcohol molecules, or to the association of water.

Dr. A. R. Martin asked if measurements of dielectric polarisation indicated whether or not association (water–water or water–alcohol) was confined to the region of high water concentration. Association would be expected throughout the whole composition range. The agreement of the results with Langmuir's theory might be due to the latitude available in the choice of values of molecular surface areas or to the choice of substances of approximately the same dipole moment.

Dr. A. R. Ubbelohde said that the practically constant increment in $RT \log f^\circ$ for each successive CH_2 group suggests that long chain alcohols in dilute solutions are not curled up, since otherwise water molecules eould not surround each CH_2 group in the same way. This agrees with the work of Staudinger on the viscosity of long chain compounds.

Dr. Butler replied that it is clear that the cohesive forces are the dominant factor in these solutions, although the dipole forces may be partly responsible for the deviation in dilute solutions. The only variable factor in the series of alcohols is the length of the hydrocarbon chain, the dipole moment being practically the same for all. The molecular polarisations of solutions of the lower members of the series with water, which have recently been investigated by Åkerlof, do not indicate any marked interaction between the dipoles. With regard to the latitude possible in the assignment of constants in Langmuir's equation, the only quantities assumed in the paper which can be varied are the relative areas of the alcohol and water molecules. There is, however, a check on these values, for the valnes employed have to give (1) a linear relation between the logarithm of the activity coefficient and the square of the surface fraction of the other component, and (2) the proper slopes of these curves. It is not possible to satisfy both of these requirements with an arbitrary

choice of these constants, and the fact that it is possible to assign relative areas which satisfy both requirements and are at the same time in reasonable agreement with the molecular dimensions is a powerful argument in favour of the theory.

The reading of the following paper was postponed owing to the lateness of the hour:

Hydrates of Calcium Sulphate. [C. S. Gibson and S. Holt.]

PERSONAL AND OTHER ITEMS

The Council of the Institute of Brewing has placed on record its appreciation of the eminent services rendered by Mr. C. G. Matthews, F.I.C. to the brewing industry during a life-long connexion with it, and has elected him an honorary member of the Institute on his retirement from active work. The Council has nominated Mr. James Stenhouse and Mr. Rowland Whitaker for re-election to the offices of president and vice-president respectively.

Mr. A. J. Rudge, a member of the Society, recently received the Ph.D. degree awarded by the University of Durham for a thesis entitled "An Investigation of the Chemistry of Rhenium, with Special Reference to its Simpler Compounds."

The death has occurred in America at the age of 61, of Mr. E. Hopkinson, vice-president of the United States Rubber Co.

The University of London has conferred the title of University Reader in Chemistry on Dr. David C. Jones, D.Sc., Ph.D., of East London College.

The University of London has awarded the degree of D.Sc. (chemistry) to Mr. A. G. Francis, an external student.

Chemical Society: Announcement

It was announced on May 18 that a communication had been received from the Committee of the van't Hoff Fund to the effect that applications for grants should be sent before November 1, 1933, by registered post to Het Bestuur der Koninklijke Akademie van Wetenschappen, bestemd voor de Commissie van het van't Hoff-fonds, Trippenhuis, Kloveniersburgwal, Amsterdam. A detailed account of the proposed manner of expenditure of the grant, and a statement of the reasons for the application should be submitted.

Royal Institution

The capital payment of £20,000 promised by the Rockefeller Foundation to the Royal Institution nearly three years ago, on condition of obtaining £50,000 from other sources, had now been received. The gift was promised for endowment of research in the Davy Faraday Research Laboratory of the Royal Institution, and the fulfilment of the promise implies that managers of the Royal Institution have been successful in securing research endowment for the Laboratory to a total capital value of upwards of £70,000. The announcement was made at the annual meeting on May 1 that the payments in connexion with the reconstruction of the Institution had been completed, and that donations and receipts from other sources for rebuilding purposes had amounted to some £93,000. The Institution has therefore acquired new funds for the joint purposes of rebuilding and research endowment in excess of £163,00[0] since the programme of reconstruction and re-equipmen[t] was begun.

Institute of Chemistry Examination Results

The following have passed the examination in Genera[l] Chemistry for the Associateship: J. H. Anderson, T. E[.] Barnes, B.Sc., T. L. Bowyer, T. F. Brown, W. D[.] Cadwallader, W. J. Carter, E. B. Colegrave, B.Sc[.], L. E. Cook, B.Sc., G. W. Cranch, M. U. Cullen, H[.] Edwards, G. R. Goodman, H. L. Haigh, D. Kirby[,] B.Sc., W. G. Longley, B.Sc., L. McGraghan, B.Sc[.], R. F. Ramsay, R. G. Rance, B.Sc., C. E. Rousseau[,] D. B. Taylor, P. F. Timson, B.Sc., H. K. Turnbul[l], J. A. Watson, G. Woodhouse.

The following have passed the examination for th[e] Fellowship: In Branch A: Inorganic Chemistry, A. S[.] Blatchford, M.Sc. In Branch C: Organic Chemistry with special reference to edible oils and fats, J. W[.] Croxford, W. D. L. Webb. In Branch E: Th[e] Chemistry, including Microscopy, of Food and Drugs and of Water, F. Brookhouse, B.Sc., D. M. Gangoll[i], M.Sc., D. D. Moir, M.Sc., R. E. Willgress, B.Sc. I[n] Branch F: Agricultural Chemistry, C. R. Louden, B.Sc[.], J. R. Mackness, Ph.D. In Branch G: Industria[l] Chemistry, with special reference to petroleum, C. W[.] Taylor, and with special reference to coal-tar technology[,] D. Baird, B.Sc. In General Analytical Chemistry[,] S. G. Burgess, Ph.D.

Road Research

It has been decided to transfer the Road Researc[h] Station at Harmondsworth from the Ministry of Trans[-]port to the Department of Scientific and Industria[l] Research as from April 1, 1933. A Road Research Boar[d] is to be constituted under the chairmanship of Majo[r] F. C. Cook, deputy chief engineer of the Roads Depart[-]ment, Ministry of Transport. The immediate directio[n] of road research will be in the hands of Mr. R. E. Strad[-]ling, D.Sc., Ph.D., director of building research under th[e] D.S.I.R., and those who have accepted invitations t[o] serve on the Road Research Board are: Prof. R. G. H[.] Clements: Mr. T. Pierson Frank (chief enginee[r] London County Council); Mr. W. J. Hadfield (cit[y] surveyor, Sheffield); Mr. W. P. Robinson (count[y] surveyor, Surrey); Prof. C. G. Cullis, D.Sc.; Mr. E. V[.] Evans, O.B.E.; Prof. E. H. Lamb; Prof. C. H. Lees[,] F.R.S.; Lt.-Col. Mervyn O'Gorman, C.B.; and Mr. T[.] Franklin Sibly. It is intended that road tests unde[r] normal traffic conditions will continue to be carried ou[t] by the Ministry of Transport and there will be clos[e] collaboration between the Ministry of Transport and th[e] Department of Scientific and Industrial Research.

Heavy Chemicals in India

The Government of India has resolved not to continu[e] the operation of the Heavy Chemical Industry (Protec[-]tion) Act of 1931, by which protective duties at differen[t] rates were placed upon certain specified chemicals wit[h] effect (except in the case of magnesium chloride) u[p] to March 31, 1933. It has been decided that the onl[y] result of continuing protection to the heavy chemica[l] industry would be to perpetuate uneconomic manu[-]facture and to place a burden on the consumer of suc[h] chemicals for an indefinite period with no prospec[t] of any national advantage.

Infra-Red Photography

An interesting development in infra-red photography in its application to the deciphering of illegible manuscripts was recently recorded in *The Times* and mentioned by Mr. Olaf Bloch at the *conversazione* of the Royal Society on May 17. The Museum photographer at the *British Museum* has been experimenting with early Egyptian texts on leather that have so far been impossible to read. The leather had curled and bubbled into a dark mass on which letters could be seen but too dimly to be deciphered. A fragment about 10 in. by 6 in. was photographed with an infra-red plate and the resulting photograph showed the writing so clearly that it could be read with ease: the success with this fragment encouraged the Museum authorities to have the whole of the particular text on leather photographed, and the photographs are now being studied in the Museum.

In a letter to *The Times*, Mr. A. E. Garrett, vice-chairman of the London Section of the Textile Institute, has provided information on another aspect of infra-red rays which may prove to be of importance in view of the success achieved with infra-red rays in the treatment of rheumatic patients. Using infra-red plates, photographs were taken inside a room, the window of which was covered in turn with various fabrics, and the results obtained show that these fabrics behave towards infra-red rays in a manner similar to that towards ultra-violet rays, the passage of the rays depending more on the porosity of the fabric than of the fibres composing it, the porosity of woollen fabrics allowing the rays to pass through them more easily than other fabrics.

Production of Synthetic Camphor in Italy

According to a report in *Die Chemische Industrie* (Apr. 22, 1933) one factory in Italy is producing synthetic camphor, the maximum capacity being 1600 t. a year. Production in 1932 was 600 t.; in 1930 it was 345 tons. About half of the camphor produced in 1932 was exported.

COMPANY NEWS

J. STONE & CO., LTD.

The accounts of the company, brass, copper, and iron founders, showed a loss during 1932 of £34,557, compared with a profit of £83,478 in 1931. The directors have recommended no dividend on the ordinary shares, last year's dividend being at the rate of 7½%.

BRITISH OXYGEN CO., LTD.

At the annual meeting of the company (cf. last week's issue of the JOURNAL for financial results), the chairman, Mr. K. S. Murray, announced the completion of the formalities involved in the purchase of Metal Industries, Ltd. and Oxygen Industries, Ltd. Dealing with the financial position the chairman said the improved results were attributed to two causes, firstly that the company was now reaping the advantages of its co-ordination with Allen Liversidge, and secondly that the efforts to develop new uses for various products were now bearing fruit. Sales of oxygen and acetylene had steadily increased throughout the year, and the supply of these two gases remained the most important part of the business. The development of other gases had been satisfactory, particularly for chemical and medical purposes. The company's engineering work and the "Sparklet" business had suffered from the depression,

MARKET REPORT

This Market Report is compiled from special information received from the manufacturers concerned.

Unless otherwise stated, the prices quoted below cover fair quantities net and naked at sellers' works.

The following alterations in prices are reported since the publication of the last Market Report (cf. CHEM. & IND., May 12, 1933, p. 427).

TAR PRODUCTS

Acid Carbolic.—Crystals.—9d.—10d. per lb. Crude 60's, 2s. 5d.—2s. 6d. per gal. 2% water—3s. 0¾d. per gal.

Benzole.—Prices at works: Crude, 9d.—9½d. per gal.; Standard motor, 1s. 4d.—1s. 4½d. per gal.; 90%, 1s. 5d.—1s. 6d. per gal.; Pure, 1s. 7½d.—1s. 8d. per gal.

Naphtha. Solvent, 90/160, 1s. 4d.—1s. 5d. per gal. Solvent 95/160, 1s. 7d.—1s. 8d. per gal. Solvent 90/190, 9d.—1s. 1d. per gal.

PHARMACEUTICAL AND PHOTOGRAPHIC MATERIALS

Acid, Tartaric.—11½d. per lb. Less 5%.

Phenacetin.—4s.—4s. 6d. per lb.

PATENT LIST

The following is a list of complete specifications of chemical interest which are open for inspection under Section 91 (4) (a) of the Patent Acts. Printed copies are not available, but photographic copies may be obtained at a charge of 8d. per page (minimum 1s.) from the Patent Office, Chancery Lane, W.C.2.

I. 8380 (1933). Prod. Chimiq. Purs. Extraction of acids and volatile substances from their aqueous solutions.

5069 (1932). World Bestos Corp. Brake linings etc.

30,675 (1932). Soc. Ital. Pirelli. Filtration of gases.

II. 30,540 (1932). Edeleanu Ges. Production of lubricating oils.

10,702 (1933). Gulf Refining Co. Manufacture of gum-inhibited motor fuels.

III. 33,936 (1932). I. G. Farbenind. Manufacture of 3 : 5-diiodo-4-pyridone.

29,034 (1932). Böhme A.-G. *See* XIII.

30,311 (1932). I. G. Farbenind. Manufacture of indole compounds.

30,915 (1932). Gutehoffnungshütte Oberhausen A.-G. Production of formaldehyde.

8078—9 (1933). Böhme A.-G. *See* XIII

IV. 31,167 (1932). I. G. Farbenind. Manufacture of aminoazo compounds.

V. 35,693 (1932). Hill. *See* VI.

30,319 (1932). Titanium Pigment Co. Paper.

31,051 (1932). Unichem Chemikalien Handels A.-G. Manufacture of duplicating papers etc.

31,395 (1932). Audubert. Making cellulose dispersions in liquids.

31,441 (1932). Brit. Celanese, Ltd. Production of ribbons, straws, etc. of cellulose derivatives.

VI. 35,693 (1932). Hill. Treatment of cotton and other fibrous materials.

31,362—3 (1932). Brit. Celanese, Ltd. Treatment of textile materials.

VII. 30,511 (1932). Roessler & Hasslacher Chem. Co. Stabilization of aqueous solutions containing hydrogen peroxide.

30,879 and 34,795 (1932). I. G. Farbenind. Production of bleaching powder.

31,066 (1932). Deberag. Manufacture of hydrogen

369,670 (1932). Carbon Dioxide Co., and anr. Apparatus for cooling and solidifying carbon dioxide.

8380 (1933). Prod. Chimiq. Purs. *See* I.

VIII *31,128 (1932). General Ceramics Co. Production* of mullite.

IX. *31,269 (1932). Straba Strassenbaubedarfs-A.-G* Producing hydraulic building materials.

X. *35,609 (1932). Krupp A.-G.* Chromium–nickel steel alloys.

337,458 (1933). Friend. Concentration of minerals.

7634 (1933). Durener Metallwerke and Meissner Malleable and age-hardenable aluminium alloys.

25,993 (1932). Firth–Sterling Steel Co. Hard metal compositions.

30,321 (1932). Kroll. Improving iron–aluminium alloys.

31,408 (1932) Brit. Thomson-Houston Co. Treatment of metals.

XI. 30,558 (1932) Brit. Thomson-Houston Co. Dielectric materials.

XIII. 29,031 (1932). Bohme A.-G. Liquids or plastic preparations.

29,099 (1932). Du Pont de Nemours & Co. Coated and impregnated materials and methods of making same.

30,512 (1932). Du Pont de Nemours & Co. Coating *compositions.*

31,029 and 31,030 (1932). Kurt Albert Ges. Production of synthetic resins from phenols and aldehydes.

7078–9 (1933). Böhme A.-G. Liquids or plastic preparations.

XIV. 12,786 (1932). Homberger. Coagulation of latex.

29,956 (1932). Du Pont de Nemours & Co. Manufacture of synthetic rubber.

XV. 12,325 (1933). Minnesota Mining & Manuf. Co. Adhesives.

XIX. 12,080 (1932) Schramm, Lauenstein, and Eyermann. Manufacture of chocolate.

23,884 (1932). Berliner. Preparation of cereals.

30,589 (1932). Feremutsch. Conversion of milk and cream into butter.

XX. 349,592 (1932). Carpmael (I. G. Farbenind.) Manufacture of hormones

23,314 (1932). Schering-Kahlbaum A.-G. Manufacture of complex double compounds of organic heavy-metal mercapto-compounds.

XXI. 28,557 (1932). S.O.S. Processing Co. Treating photographic surfaces.

GENERAL NOTES

Official Trade Intelligence

The Department of Overseas Trade (Development and Intelligence), 35, Old Queen Street, London, S.W.1, has received the following inquiries for British goods. *British firms may obtain further information by applying* to the Department and stating the specific number. *Canada:* Chemicals for the metal industry, ferro alloys and ingot metals (688); Fine and pharmaceutical chemicals (690); Industrial chemicals (691). *Latvia:* Aniline dyes and colours (713). *Norway:* Vegetable oils, soya bean (715). *Portuguese West Africa:* Lubricating oil (719).

Safeguarding of Key Industries

Representations have been made to the Board of Trade under Section 10 (5) of the Finance Act, 1926, for the exemption of ethyl cellulose and methyl cellulose from safeguarding duty. Any communication should be addressed to the Principal Assistant Secretary, Industries and Manufactures Department, Board of Trade, Great George Street, S.W.1, before June 16, 1933

The British Drug Houses, Ltd.

The British Drug Houses, Ltd. has purchased premises in Wharf's Road, King's Cross, London, with a total street frontage of 810 ft., extending also for 840 ft along the canal at Wenlock Basin. This acquisition enables the company to dispose of its buildings in Bunhill Row.

A New Cambridge Thermograph

The Cambridge Instrument Co., Ltd., of 45, Grosvenor Place, London, S.W.1, *has designed a new thermo*graph for use with a 6½ in. chart. The new model is *supplied with either plain or screwed bulb, and is arranged* for flush or wall mounting, the standard temperature *ranges covered being between* −20° *and* + 30° *C.* and 230°—340° C.

New Steel Works at Corby

Stewarts and Lloyds, Ltd. have, on the advice of their consulting engineers Messrs. H. A. Brassert & Co., Ltd., placed orders for a large modern by-product coking installation to be built at their new steelworks at Corby, Northamptonshire. The oven battery, coke screening and coke handling plant will be constructed by the Woodall-Duckham Co., the by-product recovery plant by W. C. Holmes & Co., and the coal washery and coal handling plant by Simon-Carves, Ltd.

The coke-oven battery will comprise 35 Becker ovens heated by blast furnace gas, this type of oven being the only one actually operating on blast furnace gas in Great Britain; coal storage bin, a complete set of oven machines and central quenching station. The coke screening and handling plant comprises wharf, screening station, and belt conveying systems. The by-product plant consists of gas exhausters, coolers, ammonia recovery plant for the production of sulphate of ammonia, and benzol recovery and rectification plant for the production of refined motor spirit. The coal washery and coal handling plant comprise a coal washery of 125 tons per hour capacity, with a dust extraction plant and coal storage, blending, handling, and crushing plant.

PUBLICATIONS RECEIVED

Annual Report of the Explosives Division of the Department of Mines for the Year 1932. Canada Department of Mines. Explosives Division. No. 33. Pp. 21. Ottawa: J. O. Patenaude, 1933.

Report of the National Physical Laboratory for the Year 1932. Pp. vi + 277. London: H.M. Stationery Office, 1933. 14s.

Purification of Waste Waters from Beet Sugar Factories. By E. Hannaford Richards, B.Sc., and D. Ward Cutler, M.A. Department of Scientific and Industrial Research. Water Pollution Research. Technical Paper No. 3. Pp. x + 157. London: H.M. Stationery Office, 1933. 7s. 6d.

Annual Report of the County Analyst of the County Palatine of Lancaster for the Year 1932. Pp. vi + 165. Preston: T. Snape & Co., 1933.